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Experimental Evidence on Strategic Information Avoidance

Anders U. Poulsen
Michael W. M. Roos

Studiestræde 6, DK-1455 Copenhagen K., Denmark
Tel.: +45 35 32 30 82 – Fax: +45 35 32 30 00
http://www.econ.ku.dk

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Do People Make Strategic Moves? Experimental Evidence on Strategic Information Avoidance

Anders U. Poulsen* and Michael W. M. Roos†

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Abstract

The strategic commitment moves that game theory predicts players make may sometimes seem counter-intuitive. We therefore conducted an experiment to see if people make the predicted strategic move. The experiment uses a simple bargaining situation. A player can make a strategic move of committing to not seeing what another player will demand. Our data show that subjects do, but only after substantial time, learn to make the predicted strategic move. We find only weak evidence of physical timing effects.

Keywords: Strategic moves; commitment; bargaining; strategic value of information; physical timing effects; endogenous timing; experiment.

JEL Classification: C72; C78; C90; C92; D63; D80.

1 Introduction

A crucial insight from game theory is that a player involved in an interactive situation can gain from making what Schelling (1960) calls a *strategic move*. Well-known examples are moving before someone else to get a first-mover advantage (Bagwell, 1995, Huck and Müller, 2000, and Schelling, 1960); signing contracts with third-parties (Aghion and Bolton, 1985, and Bensaid and Gary-Bobo, 1993); burning money (Ben-Porath and Dekel, 1992, van Damme, 1989, Huck and Müller, 2005); strategic delegation (Fershtman and Gneezy, 2001, Fershtman and Kalai, 1997, and Schelling, 1960);

*Corresponding author. School of Economics, University of East Anglia, Norwich NR4 7TJ, United Kingdom. E-mail: a.poulsen@uea.ac.uk. Poulsen is affiliate researcher at the Centre for Experimental Economics at University of Copenhagen. We thank the Editor Jordi Brandts and two referees whose very valuable comments and suggestions significantly improved the analysis of the data and the overall exposition of the paper. All errors are of course ours. We wish to thank Niels Bruhn Christensen for invaluable help with the design and the programming. Thanks to Chaim Fershtman, Werner Güth, and Hans-Theo Normann for their comments. Toke Fosgaard, Mads Harmsen, and Frederik Øvlisen from the LEE lab in Copenhagen gave professional lab assistance. Financial support from the Danish Social Science Research Council (Poulsen) is gratefully acknowledged.

†Fakultät für Wirtschaftswissenschaft, Ruhr-Universität Bochum, D-44780 Bochum, Germany.

changing the information structure (Hauk and Hurkens, 2001, Hurkens and Vulkan, 2006, and Schelling, 1960) or controlling the flow of information (Brocas and Carrillo, 2007).

These important game-theoretic results about strategic moves lead naturally to the question: Do players in practice understand the usefulness of making such strategic moves? This is, we believe, a non-trivial issue: the strategic moves mentioned above involve a deliberate restriction of one's freedom of action, a reduction of one's payoffs in certain outcomes, or an avoidance of information. Such moves may appear irrational and unattractive, and players may consequently avoid them. Also, bounded rationality or cognitive biases could lead players to underestimate or completely ignore the impact of the strategic move on the other players' behavior. Such biases have been experimentally documented in other, mostly non-strategic, decision problems. See Loewenstein, Moore, and Weber (2006) and the references therein.

It seems highly relevant to investigate if players understand the strategic role of information since many important interactive economic situations involve decisions about how much information to collect. Some examples are negotiators engaging in fact finding missions before sitting down at the negotiating table, and bidders going to viewing days to get a feel for the value of the items on sale (see Hauk and Hurkens, 2001, and Hurkens and Vulkan, 2006). It is useful when considering such situations to know the extent to which players make the theoretically predicted strategic move since deviations from the prediction could have sizeable economic implications for the players.

To shed empirical light on these questions we conducted an experiment using a simple bargaining situation based on the Nash Demand Game (Nash, 1953). In our first treatment a player, B, has the opportunity to make a strategic move of seeing or not seeing what another player, A, has demanded before player B makes a demand, and this strategic move is observed by player A before he makes his own demand. We call this move strategic information avoidance. Our second treatment is the same as the first except for the fact that player B's strategic move is not observed by player A. The theoretical model predicts that player B avoids information in the first and obtains it in the second treatment. The crucial role of the visibility of the strategic move was emphasised early on in Schelling (1960). We also test a related theoretical result and intuition, namely that behavior in the situation where player B's strategic move is not observed by player A is the same as in the situation where player B makes the strategic move *after* player A has moved. This hypothesis is of some interest since experimental research have shown that the order of moves can influence behavior although game theory predicts it should not; see for example Güth, Huck, and Rapoport, 1998, Weber, Camerer, and Knez, 2006, and Huck and Müller, 2005. This is referred to as 'physical timing effects' or 'virtual observability'. Finally we consider the hypothesis that when player B's strategic move is unobserved players behave in the same way as in the situation where player B has no commitment option available.

Other experimental papers have studied issues related to strategic moves and information acquisition. Fischer, Güth, Müller, and Stiehler (2006) consider the case where a second mover is with a certain probability informed about the first mover's action. Fonseca, Müller, and Normann (2006) consider the choice of when to move (endogenous timing), and hence how much information to possess, in a duopoly game.

Studying the ultimatum game Poulsen and Tan (2007) consider the decision of Proposers whether or not to learn the Responders' smallest acceptable offers. We discuss how our experiment relates to these contributions in Section 6 below.

The main purpose of the experiment is to see if people make the predicted strategic move in the various strategic environments described above. Our experimental findings can be summarized as follows: First, players learn to correctly distinguish between situations where being informed is optimal and those where it is best to avoid information. It does however take more time for players to learn to avoid harmful information than it does for them to learn to obtain beneficial information; indeed, in the latter case most players make the optimal strategic move right from the start. Second, we find no evidence of a persistent physical timing effect. We find some weak evidence of such an effect in the initial periods of the experiment but it becomes insignificant over time. Finally, we find as predicted by game theory no significant behavior differences between the case where commitment is unobserved and when no commitment is available at all. Overall, our findings show that players' make the predicted strategic moves when they have sufficient time to understand the situation and to learn the appropriate behavior. Game theory seems to correctly predict the strategic moves people make, at least in the simple situations investigated in our experiment.

The rest of the paper is organized as follows. In Section 2 we develop the theoretical background. Section 3 formulates our hypotheses and Section 4 describes the experiment. Section 5 reports our findings and these are discussed and related to the existing literature in Section 6. Section 7 concludes and outlines some possible future research. The Appendix contains proofs.

2 Theoretical Predictions

2.1 The Games

Our experiment is based on four games: A game where a player's strategic move is made and observed by the other player before the latter chooses an action (called the 'Commitment game'); a second game where the strategic move is made at the same time as in Commitment game but is unobserved ('Unobserved Commitment'); a third game where the strategic move is made after the other player has decided on an action, and hence is trivially unobserved ('No Commitment'); and, finally, a game where no strategic move is available ('Benchmark'). In what follows we describe these games more precisely and develop some predictions.

There are two players, A and B, and a sum of money, denoted X. Let $\epsilon > 0$ denote the smallest monetary unit. The set of feasible demands is $D = \{0, \epsilon, 2\epsilon, ..., X - \epsilon, X\}$. We assume that X is even, that ϵ is such that $X/2 \in D$, and that $\epsilon < X/2$. Denote player i's demand by x_i, $i = A, B$, where $x_i \in D$. If $x_A + x_B \leq X$, each player gets what he demanded. If $x_A + x_B > X$, each player gets zero. We assume all players are rational and seek to maximize their expected money earnings, and that this is common knowledge.

2.1.1 The Commitment Game (C)

In the C game player B first irrevocably decides whether or not to see the demand that player A will make. We refer to this as player B's information decision. Player A observes which information decision player B made, and then player A makes his demand. Player B then sees player A's demand or not, as determined by his information decision. Finally player B makes his demand.

2.1.2 The Unobserved Commitment Game (UC)

In the UC game Player B first irrevocably decides whether or not to see player A's demand, as in the Commitment game. Player A does however not learn player B's information decision. In other words, player A knows that player B has made *some* information decision (to see or not to see player A's demand), but player A does not know *which* information decision player B made. Then player A makes a demand. After this player B sees player A's demand or not, as determined by player B's information decision. Finally player B makes his demand.

Any difference between behavior in the C and UC game is due to the observability or otherwise of player B's information decision.

2.1.3 The No Commitment Game (NC)

In the No Commitment game player B has no opportunity to commit to see player A's demand or not before player A makes a demand. The order of moves are: player A first makes a demand. Then player B decides whether or not to see player A's demand. Finally, player B makes his demand.

The UC and NC games are strategically equivalent. Any difference in behavior is solely due to a physical timing effect, as described in the papers mentioned in the Introduction.

2.1.4 The Benchmark Game (BM)

The Benchmark game is a sequential Nash demand game with perfect information. Player A first makes a demand. Player B sees player A's demand, and then player B makes his demand.

2.2 Equilibria

There is a multiplicity of Nash equilibria in our bargaining games. To obtain a unique prediction we select among equilibria by making some assumptions. The first one is specific to the Commitment game. Suppose player B decides not to see player A's demand. It is then common knowledge in the subgame that follows that player B has not seen player A's demand when player B makes his demand. Any feasible pair of demands (x_A, x_B) such that $x_A + x_B = X$ is a Nash equilibrium of this subgame.

We assume players in this subgame select the Nash equilibrium where each player demands half the surplus. This assumption can be justified by noticing that it is the only equilibrium that equates the players' earnings (apart from the implausible equilibrium where each player demands the entire surplus), and this makes it a 'focal' equilibrium (Schelling, 1960).

The second assumption is that players do not play dominated strategies. Given these assumptions we obtain the following predictions for our games. We first characterize the BM game since this makes it easier to characterize the Commitment game.

Proposition 1. *a. The Benchmark game has two pure-strategy subgame-perfect equilibria. In the first subgame-perfect equilibrium player A demands $x_A^* = X$, and player B demands $x_B^* = X - x_A$ for any demand x_A made by player A. In the second subgame-perfect equilibrium player A demands $x_A^* = X - \epsilon$, and player B demands $x_B^* = X - x_A$ for any demand $x_A < X$, and makes some demand $x_B^* > 0$ for $x_A = X$. In any subgame-perfect equilibrium of the Benchmark game player B therefore gets at most ϵ and player A gets at least $X - \epsilon$.*

b. The subgame-perfect equilibrium of the Commitment game is: Player B decides not to see player A's demand, and player B demands half of the money when it is his turn to make a demand; if player A observes that player B decided not to see player A's demand, player A demands half of the money; and if player A observes that player B decided to see player A's demand, then one of two subgame-perfect equilibria of the ensuing subgame, which is similar to the Benchmark game, is played.

c. The unique equilibrium in undominated strategies of the UC game is that player B decides to see player A's demand, and the players' equilibrium demands are identical to those in the Benchmark game.

d. The unique equilibrium in undominated strategies of the NC game is the same as that for the UC game.

Proof: Please see the Appendix.

3 Hypotheses

We use four treatments corresponding to our theoretical games: The Commitment (C), the Unobserved Commitment (UC), the No Commitment (NC), and the Benchmark (BM) treatment. Based on the theoretical results in the previous section we formulate the following hypotheses:

Hypothesis 1 (information decision): Player B avoids information about player A's demand in the C treatment, but obtains the information in the UC treatment.

Hypothesis 2 (no physical timing effect:) Player B makes the same information decision in the NC treatment as in the UC treatment.

Hypothesis 3 (demands): Part A: If in the C treatment Player B decides not to see player A's demand then each player demands half the surplus. **Part B:** Player

A and B demands in the Benchmark treatment equal those in the C treatment when player B decides to see A's demand. These in turn equal the demands in the UC and NC treatments.

The first half of Part B in Hypothesis 3 follows from the fact that the subgame played in the C game when player B sees player A's demand is identical to the BM game.

4 Experimental Procedures

The experiments took place in the spring and fall of 2006 at the Laboratory for Experimental Economics (LEE) at University of Copenhagen, Denmark. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). The ORSEE system (Greiner, 2004) was used for recruitment.

4.1 Subjects

In total 254 subjects, recruited from across the University of Copenhagen, participated in the experiment. Subjects received a show-up fee of 50 Danish Kroner (DKK), equal to about US $ 9 at the time of the experiment. On average a session lasted 45 minutes. There were 4 sessions with 74 subjects for the Benchmark treatment. For the C (UC) [NC] treatments sessions and subjects numbers were 4 and 72 (3 and 44) [4 and 64]. Average earnings across all treatments, including the show-up fee, was DKK 171.6, or about US $ 30.9.

4.2 Experimental Procedure

After entering the laboratory each subject was seated in front of a computer. All computers were separated by cubicles and no verbal or visual communication between subjects took place during the experiments. Once all subjects had read the instructions, a test was distributed. When all students had answered the test questions the experimenters checked all answers. If a subject gave an incorrect answer to a question, he was asked to try again. Any questions about the instructions or the test were answered privately. Once all subjects had answered all test questions correctly, this was announced and the experiment began.

The experiment consisted of 15 periods. At the start of the experiment each subject was randomly given the player A or the player B role. A subject stayed in the same role for all 15 periods. In each period one A player was randomly matched with a B player. The set of feasible point demands was $\{0, 1, 2, ..., 99, 100\}$ (i.e. $X = 100$ and $\epsilon = 1$). At the end of each period both players were informed about each other's demands, about player B's information decision, and about their own point earnings. After the last period the points a player had earned in each period were summed and converted into Danish Kroner (DKK), using the following exchange rate: 5 points is equal to DKK 1 (so 100 points equals DKK 20, or about US $ 3.6). After the experiment this number of Danish Kroner was, together with the show-up fee, paid privately to each subject in a separate room.

5 Experimental Results

5.1 Player B's Information Decision

Figure 1 shows for each of the 15 periods the percentage of B players who decided not to see player A's demand in the C, UC, and NC treatments.

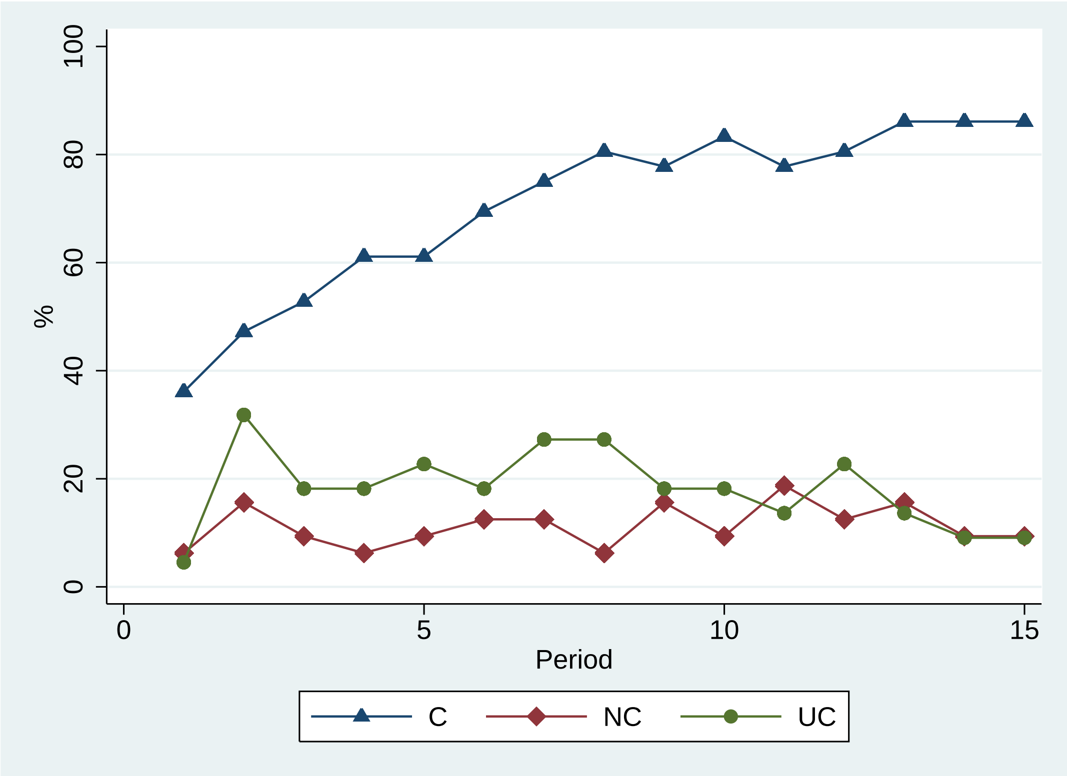

Figure 1: Percentage of B players who decide not to see player A's demand in the C, UC, and NC treatments.

In the C treatment less than 40 % of B players initially avoid seeing player A's demand. This percentage rises steadily over time, and towards the end more than 85 % of the B players avoid seeing player A's demand. The average across all periods is 70.7 %. Behavior in the two other treatments differ markedly: in the NC treatment the percentage fluctuates between 5 and 20 %. The average is 11.2 %. In the UC treatment there is a initially a slight increase in the percentage of B players who avoid information, but the percentage seems later to stabilize around 10 %. The average is 18.2 %.

To put these results on a firmer footing, and to study the dynamics of individual behavior over time, we proceed with an econometric analysis of player B's information decision. We first regress the fraction of B players who decide not to observe player A's demand in period t, denoted NO_t, on treatment dummies T_i, $i = UC, NC$ (the C treatment is the reference group), and a linear time trend, $PERIOD_t$:

$$NO_t = \beta_0 + \beta_1 T_{UC} + \beta_2 T_{NC} + (\beta_3 + \beta_4 T_{UC} + \beta_5 T_{NC}) PERIOD_t + \varepsilon_t. \qquad (1)$$

	β_0	β_1	β_2	β_3	β_4	β_5	ρ	R^2	DW_o	DW_t	#
coeff	.41	-.27	-.33	.035	-.035	-.033	.69	.50	.56	2.41	165
σ	.10	.13	.11	.007	.007	.007					
p	.003	.071	.015	.000	.000	.001					

Table 1: Aggregate behavior. ρ denotes the coefficient of the first-order autoregressive error term; DW_o is the Durbin-Watson statistic of the original model with $\rho = 0$; DW_t is the Durbin Watson statistic for the transformed model controlling for autocorrelation; σ are robust standard errors adjusted for cluster effects.

This specification allows us to compare the UC and NC treatments with the baseline C treatment.[1]

The results of estimating (1) are summarized in Table 1. The intercept β_0, which measures the initial fraction of B players that make the predicted strategic move of not seeing player A's demand, is significantly larger than zero but also significantly smaller than one (Wald test, $p = 0.0002$). This means that at the beginning of the experiment a large fraction of B players do not make the predicted information decision. Nevertheless, as the trend coefficient β_3 is positive, more and more B players make the predicted information decision over time. On average, the share of these B players increases by 3.5 percentage points in each period. This can be interpreted as evidence that B players learn to behave strategically over time. The 15 periods, however, are not enough for every subject to learn the strategic move: the trend prediction, $\beta_0 + 15\beta_3 = 0.935$, is still significantly smaller than one (Wald test, $p = 0.0026$).

In the UC treatment the initial fraction of B players who decide not to see player A's demand is much lower than in the C treatment. In fact, the intercept for the UC treatment, $\beta_0 + \beta_1 = 0.14$, is not statistically different from zero (Wald test, $p = 0.1327$). This means that on average B players in the UC treatment make the commitment decision that is theoretically predicted. Moreover, this behavior does not change over time as there is no significant trend ($\beta_3 + \beta_4 = 0$, Wald test, $p = 0.638$).

Studying the aggregate proportion of B players who make the predicted strategic move tells us little about the nature of any learning. Although as just seen there is an aggregate trend in the data, individual subjects could switch back and forth between the two information decisions, contradicting that they actually learn how to behave optimally. To test for learning, we estimate a panel probit model for the probability that player B individual i in period t decides not to observe player A's demand as a function of time. If this probability is positively related to the time variable this provides evidence that the individual has learnt over time. Moreover, we would expect that a subject who learnt to make the optimal information decision sticks to this choice.

[1] Two econometric problems arise when we want to estimate this model with data pooled over time and across sessions. First, there may be session-specific effects, due to the repeated interaction of the same individuals within a session. In order to control for such potential session effects, we correct for intra-group correlation (such correlation would otherwise violate the assumption of independent observations) by using the clustered sandwich estimator for the standard errors. Second, if some dynamic effects are not captured by the linear time trend there will be autocorrelation in the error term. We deal with this potential problem by assuming first-order autocorrelation in the error term and using the Prais-Winston estimator to estimate the model.

If so, the probability of making the predicted information decision of not seeing player A's demand should depend positively on having made this information decision in the previous period.

Denoting the decision by player B individual i to not see player A's demand at time t by no_{it}, a straightforward model to test for individual learning is the following panel probit model:

$$P(no_{it} = 1|\mathbf{x}_{it}) = G(\gamma_0 + \gamma_1 no_{it-1} + \gamma_2 PERIOD_t), \tag{2}$$

where $G(\cdot)$ is the standard normal cumulative distribution function. If individuals learn, we should expect $\gamma_1 > 0$ and $\gamma_2 > 0$.

A potential problem with this specification is that the individual observations may not be independent.[2] We deal with this by explicitly modeling the potential source of dependence. The independence assumption may be wrong if B players use past experience to update their beliefs about how A players respond to the B players' information decision. If B players change their beliefs and their information decision in response to their past earnings experience, this is equivalent to saying that they learn to make the predicted information decision. If we include a plausible measure of past experience with each information decision, we can capture the presence of learning, and this should ensure independent errors.

For each period t we compute the average payoff that B player i received after choosing to observe player A's demand:

$$\overline{\pi}^o_{it} = \frac{\sum_{\tau=1}^{t} o_{i\tau}\pi_{i\tau}}{\sum_{\tau=1}^{t} o_{i\tau}},$$

where $o_{i\tau}$ is an indicator function equal to 1 if player B chose to observe player A's demand in period τ and 0 otherwise. Analogously, we define $\overline{\pi}^{no}_{it}$ as the average payoff of player B after choosing not to observe the demand of player A. Both measures capture the earnings feedback player B receives after having made the information decision. We therefore estimate an alternative panel probit model for the B subjects in the C treatment:

$$P(no_{it} = 1|\mathbf{x}_{it}) = G(\delta_0 + \delta_1 PERIOD_t + \delta_2 \overline{\pi}^{no}_{it-1} + \delta_3 \overline{\pi}^{o}_{it-1}). \tag{3}$$

Theoretically, we expect $\overline{\pi}^{no}_t > \overline{\pi}^o_t$. If there is learning based on past earnings ('reinforcement' learning), then subjects should pursue the optimal information decision and avoid the inferior one. In that case we expect $\delta_2 > 0$ and $\delta_3 < 0$. However, subjects might during the course of the experiment come to *understand* that the strategic move of not seeing A's demand is optimal, irrespective of their past earnings experience. In that case $\delta_1 > 0$ should hold.

Table 2 presents the results of the panel probit estimations for the C treatment[3].

[2] We thank an anonymous referee for stressing this point.

[3] All the models were also estimated with session dummies in order to control for session effects, but the dummies were never significant at the conventional 5% level.

	1	2	3	4	5
$cons$	-.61	-.80	-1.01*	-.29	.40
	(.38)	(.61)	(.42)	(.68)	(.44)
no_{it-1}	.79**				
	(.27)				
$PERIOD_t$	.17**	.08	.10**	.23**	.11*
	(.04)	(.04)	(.04)	(.03)	(.05)
$\overline{\pi}^{no}_{it-1}$		.05**	.05**		
		(.01)	(.01)		
$\overline{\pi}^{o}_{it-1}$		-.00		-.03	
		(.01)		(.02)	
$\overline{\pi}^{no}_{it-1} - \overline{\pi}^{o}_{it-1}$					.03**
					(.01)
$Pseudo\ R^2$	.23	.22	.22	.22	.19
AIC	299.8	136.7	163.3	268.9	140.1
#	504	257	389	372	257

Table 2: Individual behavior. Standard errors in parentheses. AIC: Akaike Information Criterion. ** 1%, * 5%

The estimated coefficients of model (2) are reported in the first column. All are significantly positive, as expected. The probability of making the predicted information decision increases over time and it is also positively related to having made this information decision in the previous period. This is evidence for learning at the individual level.

Model (3) is estimated in the table's second column. Only the estimate of δ_2 is significantly positive. The period coefficients δ_1 and δ_3 are insignificant at the 5% level. This is evidence of learning through positive earnings feedback. As a robustness check we also estimate the model with the each of the two experience variables individually (see the third and fourth column). The trend coefficient is once more positive. If we only include $\overline{\pi}^{o}_{it-1}$ the estimated coefficient is negative, as expected, and significantly different from zero at $p = 0.065$.

Instead of recalling and being influenced by the previous payoffs from each information decision separately, subjects may consider the difference between the average payoffs, $\overline{\pi}^{no}_{it-1} - \overline{\pi}^{o}_{it-1}$. To test this hypothesis we estimate the model with the constraint $\delta_2 = -\delta_3$; see the fifth column. The estimated coefficient of the difference between the average profits is significantly positive and so is the trend.

In conclusion, not only do more subjects in the C treatment make the predicted information decision over time, they seem to learn this based on past experience. Furthermore, since the trend coefficient is significantly positive there seems to be an additional kind of learning taking place, which we attribute to an enhanced understanding over time of the structure of the game itself. We can summarise all the above in

Result 1. *There is clear evidence that B players in the Unobserved Commitment treatment make the predicted strategic move of seeing player A's demand, and that B players in the Commitment treatment learn to make the predicted strategic move of* *not seeing player A's demand. We fail to reject Hypothesis 1.*

5.2 Physical Timing Effects

The difference in physical timing between the UC and the NC games could make player B more likely to avoid seeing player A's demand in the UC than in the NC treatment. Figure 1 shows that on average and especially in the earlier periods fewer B players decide to see player A's demand in the UC than in the NC treatment. Over time however behavior in the UC and NC treatments become indistinguishable. Indeed, based on the estimation of model (1) in the previous section, the joint hypothesis $\beta_1 = \beta_2$ and $\beta_4 = \beta_5$ cannot be rejected (Wald test, $p = 0.631$). We find no evidence in favour of a physical timing effect. Summarizing, we can formulate

Result 2. *There is no evidence of a persistent physical timing effect. We fail to reject Hypothesis 2.*

The results from the existing experimental literature can help explain why there is no persistent physical timing effect in our experiment. Our bargaining game is sequential and asymmetric, so physical timing cannot work as a symmetry breaker, as in Huck and Müller (2005). Moreover, since player B in all treatments makes his demand after player A, player B is in a relatively weak position, as the Responder in the Ultimatum Game (of course, due to reciprocity and fairness concerns they in practice get a higher payoff than what is theoretically predicted). The fact that player B in the UC treatment makes his information decision before player A makes his demand can not, according to the data, compensate for this weakness. Finally, not seeing player A's demand is a weakly dominated strategy for player B and, as pointed out by Güth, Huck, and Rapoport (1998), this weakens any physical timing effect. See also the findings in Weber, Camerer, and Knez (2006) and Huck and Müller (2005).

5.3 Demands

5.3.1 Hypothesis 3A

Figure 2 shows player A's and B's average demands in each period in the C treatment conditional on whether or not player B decided to see player A's demand. Figure 3 shows the relative frequency distributions of player A and B demands. In the C treatment player A demands 50 points in 343 out of the 382 cases (89.8%) where player B decided not to see player A's demand. Player B demands 50 points in 337 out of the same 382 cases (88.2%). Pooling all player A and B demands across periods, player A and B on average demand 49.5 and 50.2 points respectively when player B decided not to see player A's demand. When player B decides to see player A's demand, the average across-period player A and B demands are 63.3 and 42.8, respectively.

In order to test for these and other differences we estimate a panel regression model:

$$x_{k,it} = \alpha_0 + \alpha_1 T_C + \alpha_2 T_{UC} + \alpha_3 T_{NC} + (\alpha_4 T_C + \alpha_5 T_{UC} + \alpha_6 T_{NC}) no_{it} + \varepsilon_{it}, \qquad (4)$$

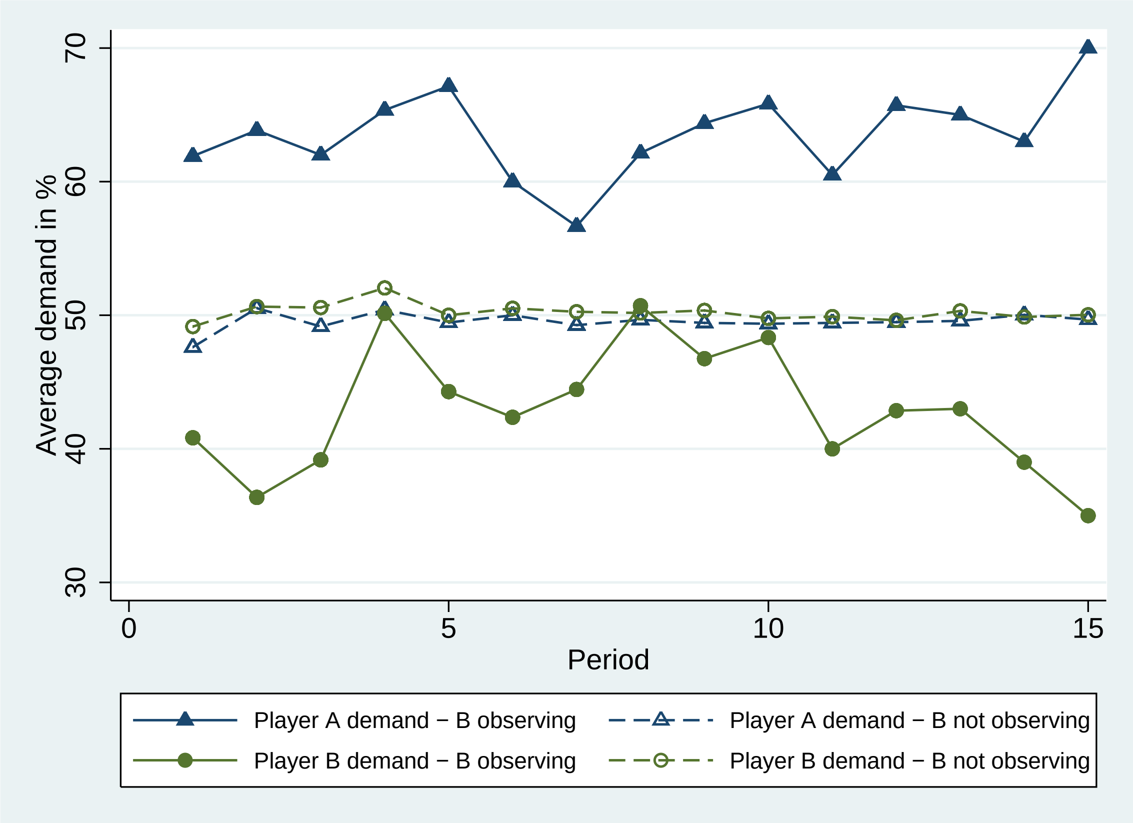

Figure 2: Average player A and B demands in the C treatment, conditional on player B's information decision.

where $x_{k,it}$ is the demand of player i of type $k = A, B$ in period t, T_j with $j = C, UC, NC$ are treatment dummies (with BM as the reference treatment), and no_{it} an indicator variable taking the value 1 when player B decides not to see player A's demand.[4]. Table 3 shows the results.

The coefficient α_4 is for both player A and player B different from zero at any conventional significance level, indicating, as shown in Figure 2 and 3, that player B's information decision clearly impacts on both players' subsequent demand behavior in the C treatment. We cannot reject the hypothesis that both players coordinate on the 50:50 split when player B makes the strategic move of not seeing player A's demand, as $\alpha_0 + \alpha_1 + \alpha_4$ is not different from 50 (Wald tests, $p = 0.632$ for x_A and $p = 0.417$ for x_B).

Result 3. *In the C treatment there is strong evidence that the 50:50 split is focal when player B does not see player A's demand. We cannot reject Hypothesis 3A.*

[4]We estimate a random effects model by GLS with robust standard errors adjusted for cluster effects in the sessions. The Breusch-Pagan LM test strongly rejects the null hypothesis of no random errors. The model was estimated with a linear time trend, but the trend coefficient is not significantly different from zero, which means that the demands do not change over time within the treatments. We also tested for autocorrelated error terms using the Wooldridge (2002) test for serial correlation in panel-data models, but did not find evidence of autocorrelation at any conventional significance level.

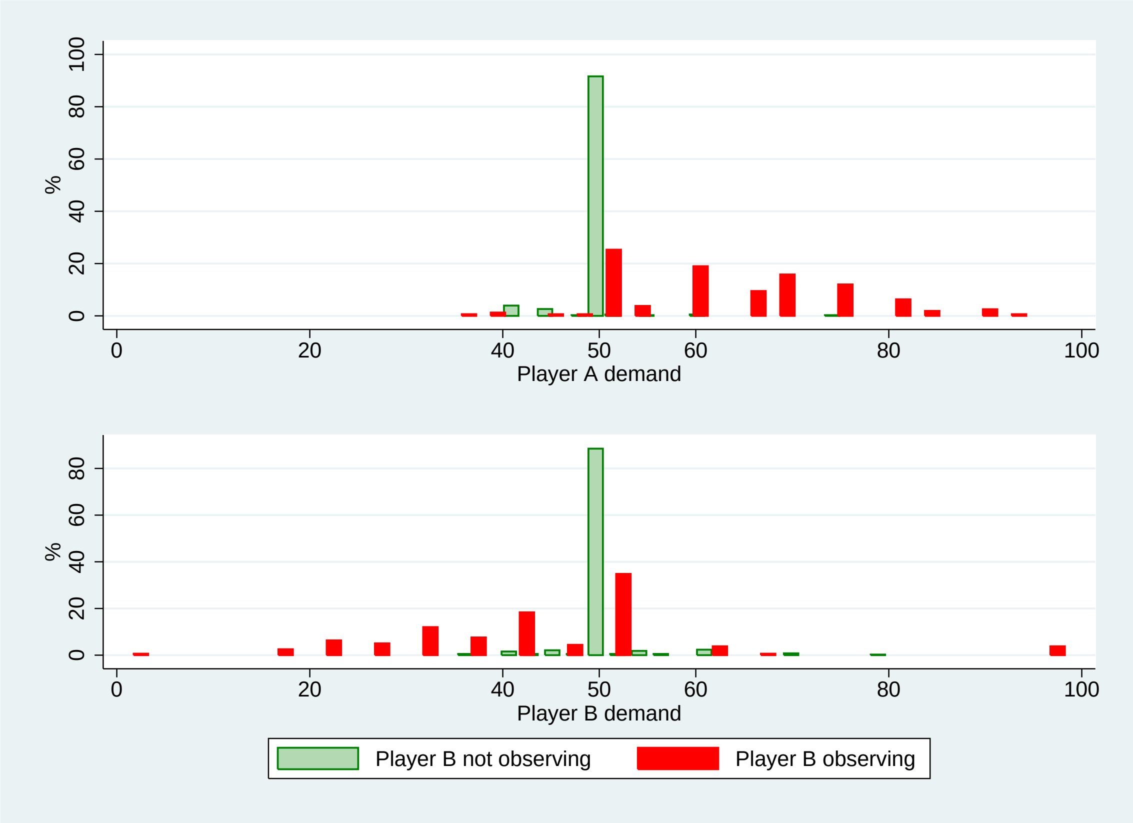

Figure 3: Relative frequency distributions of player A and B demands in the C treatment, conditional on player B's information decision.

5.3.2 Hypothesis 3B

Table 4 shows the average player A and B demands (denoted $\overline{x}_A$ and $\overline{x}_B$), average point earnings ($\overline{\pi}_A$ and $\overline{\pi}_B$), and average efficiency ($\overline{\pi}_A + \overline{\pi}_B$) in the treatments. In the UC and NC treatments player A's demands do, by definition, not vary with player B's information decision. The player B point earnings in the first and the last row differ only in the second decimal (they equal 34.62 and 34.64, respectively).

If player B in the C treatment decides to see player A's demand, the game is the same as the BM game, so demands should be indistinguishable. This is what we find in Table 3, as the dummy for the C treatment, α_1, is not significantly different from

		α_0	α_1	α_2	α_3	α_4	α_5	α_6	R^2	#
	coeff	60.33	2.97	-.57	-.60	-13.61	1.42	-.80	.18	1905
x_A	σ	1.45	2.23	2.75	2.10	1.73	1.39	.95		
	p	.000	.181	.837	.776	.000	.307	.402		
	coeff	43.93	-1.33	.14	3.73	8.24	4.81	1.76	.05	1905
x_B	σ	1.67	2.24	2.61	1.99	1.85	.65	1.51		
	p	.000	.553	.957	.061	.000	.000	.245		

Table 3: Individual player A and B demands. Panel estimations with random effects; robust standard errors adjusted for cluster effects.

	$\overline{x}_A$	$\overline{x}_B$	$\overline{\pi}_A$	$\overline{\pi}_B$	$\overline{\pi}_A + \overline{\pi}_B$
BM	60.2	43.4	48.9	34.6	83.5
C: player B does not see A's demand	49.6	50.2	46.1	46.3	92.4
C: player B sees A's demand	63.3	42.8	45.9	31.2	77.1
UC: player B does not see A's demand	59.9	49	23.8	21.4	45.2
UC: player B sees A's demand	59.9	43.6	46.6	33.7	80.3
NC: player B does not see A's demand	59.5	48.7	28.3	25.9	54.2
NC: player B sees A's demand	59.5	47.2	46.3	34.6	80.9

Table 4: Average player A and B demands, point earnings, and efficiency, computed as averages across all periods.

zero for both player A and B.

Result 4. *When in the C treatment player B decides to see player A's demand, demands are equal to those in the Benchmark treatment. We cannot reject the first part of Hypothesis 3B.*

Consider next the demands in the UC and the NC treatment when player B decides to observe player A's demand. Player A demands are not different between the two treatments as $\alpha_2 = \alpha_3$ cannot be rejected (Wald test, $p = .992$) Since both coefficients are not significantly different from zero there is also no difference from the BM treatment. For player B, the demand in the NC treatment is slightly higher than in the BM treatment, but again there is no significant difference between NC and UC (Wald test, $p = 0.104$). Comparing C with NC and UC, the only significant difference is that B players in the NC treatment make larger demands than those in the C treatment, $\alpha_1 < \alpha_3$ (Wald test, $p = 0.004$). This difference can be attributed to the fact that if player B decides to be informed player A knows this in the C but not in the NC treatment; player A then reacts by making larger demands in C than in the NC treatment and player B responds by demanding correspondingly less in C than in the NC treatment. This is consistent with $\alpha_1 > \alpha_3$ for player A, although the difference is not statistically significant.

Result 5. *When in the UC and the NC treatment player B decides to see player A's demand, player A demands are equal in the C, UC, and NC treatments. Player B's demands are equal in the UC and BM and in the UC and NC treatments. However, demands in the NC treatment are larger than those in the BM and C treatments. We cannot reject the second part of Hypothesis 3B for player A, but (weakly) do so for player B.*

Let us consider efficiency. As shown in Table 4, efficiency is 92.4 % when player B in the C treatment decides not to see player A's demand. In the Benchmark treatment efficiency is 83.5. Pooling all observations across time, we find that the difference in these percentages is highly significant (Chi-square test, $df = 1$, $X^2 = 18.2$, $p < 0.001$). When player B in the C treatment sees player A's demand efficiency is only 77.1 %. Comparing with the Benchmark treatment the difference is again very significant (Chi-square test, $df = 1$, $X^2 = 4.36$, $p < 0.05$). Overall, efficiency in the C treatment is 87.4 %. On comparing with the Benchmark treatment the difference is once more highly significant (Chi-square test, $df = 1$, $X^2 = 4.28$, $p < 0.05$). The explanation for the efficiency difference between the Benchmark treatment and the C treatment when player B avoids seeing player A's demand is quite straightforward. In the Benchmark treatment player B frequently 'rejects' large player A demands by deliberately demanding more than the residual. These rejections seem to be driven by the same reciprocity and fairness concerns that are observed in the ultimatum game. In the Benchmark treatment about 22 % of B players demand more than 35 when player A demands 65; if player A demands 70, 75, or 80 the percentages are 32, 35, and 70 %. This reduces efficiency. In the C treatment, on the other hand, when player B commits to not see player A's demand the players avoid disagreement by coordinating on the equal split.

6 Discussion

Our work is related to several other contributions. Using a sequential bargaining game Fischer, Güth, Müller, and Stiehler (2006) experimentally vary the probability that the second mover will observe the first mover's choice (see also Güth, Müller, and Spiegel, 2006). In their setup the probability with which the first mover's choice will be seen by the second mover is exogenous. Our paper is related to theirs in that it provides an answer to the question: if the second mover could influence the probability of observing the first mover's demand, would the second mover understand that it would serve his or her interests best to set the probability equal to zero? Our theoretical answer is that the second mover should decide not to see the first mover's action when this decision is observed by the first mover, and our data show that subjects learn to understand this.[5]

Poulsen and Tan (2007) use the ultimatum game to study if information acquisition interacts with fairness considerations. In their main treatment the Responder commits to a smallest acceptable offer (SAO), and the Proposer decides at the same time whether or not to observe the Responder's SAO. Poulsen and Tan consider if fairness concerns influence if players decide to obtain information that is predicted to be useful for a decision maker seeking to maximize expected money earnings, but they do not consider if harmful information is avoided. The main innovation of the current experiment is the C treatment, to which there is no analogue in Poulsen and Tan's experiment.[6]

Our paper is also related to the literature on games with endogenous moves ('timing games'). See for example Fonseca, Huck, and Normann (2005) and Fonseca, Müller, and Normann (2006). In these (mostly duopoly) games, the order of moves is endoge-

[5] In the light of the setup in Fischer et. al. (2006), it could be interesting to adapt our model such that player B, instead of making a yes/no information decision, decides on a probability of seeing player A's demand. In the C game, player A then observes the probability but not the realization. This version would correspond to the setup in Fischer et. al. (2006) if the observation probability in the latter model were chosen by the second mover and so endogenous. We conjecture that the second mover would then decide to set the probability equal to zero, as is done in the C game. I thank Werner Güth for indicating this relationship between the models.

[6] In Poulsen and Tan's 'Information' treatment the Proposer commits to seeing the Responder's SAO or not and the Responder decides on a SAO. The Proposer then makes an offer either seeing the SAO or not as decided at the first stage and the offer is then accepted or rejected by the Responder according to the chosen SAO.

nous. The literature seeks to understand whether sequential or simultaneous move games arise. In our design the order of moves is fixed and players instead decide on how much they would like to know when making a move. Nevertheless, from a game-theoretic point of view moving after another player but not knowing what the player did is the same as moving simultaneously. Our design is therefore the same as a timing game where one player moves first and the other player decides between being an informed second mover or to move at the same time as the first player.[7] Our data show that the predictions made by the theory of endogenous timing are, when sufficient learning has taken place, borne out for our bargaining experiment: players learn that if the other player can condition his decision on one's timing decision it is better to move at the same time as the other player than to wait and see what he or she did.

To which extent does our main finding, that players learn to optimally condition their strategic move on the strategic environment, generalize to other strategic situations? It is instructive to compare our findings with those from Fonseca, Müller, and Normann (2006). In their two-period duopoly quantity-setting game with observable delay (Hamilton and Slutsky, 1990) the unique equilibrium is that both players produce in period 1; in fact, moving in period 1 is a dominant strategy. In spite of this a substantial proportion of subjects decide to wait and move in period 2. The authors offer several explanations for their finding, such as inequality aversion and a preference for waiting, in order to resolve strategic uncertainty about the order of moves, although this is disadvantageous.

It is not entirely clear why our results differ from those in Fonseca, Müller, and Normann's experiment. One explanation, pointed out by an anonymous reviewer, is that it can be easier for players to understand the value of commitment in some environments, such as our bargaining environment, than in other more complex situations. In a simple bargaining situation such as those captured by the Nash demand game a player will, after some learning, come to understand that deciding to move second makes one vulnerable to exploitation by first movers; in a duopoly game on the other hand players must not only learn this but must also at the same time learn the more complex underlying relationship between the players' output choices and profits. This hypothesis is consistent with the finding in Fonseca et. al. (2006) that the proportion of players who decide to wait falls but only very slowly. Understanding which strategic contexts are conducive for learning strategic moves and which ones are not seems a fruitful area for future research.

7 Conclusion

Game theory predicts that rational and self-interested players optimally exploit any strategic commitment opportunity. Strategic commitments, such as 'burning the bridge', can however appear counterproductive or be too cognitively demanding for people to use in practice. We conducted a simple experiment using a simple bargaining game to see whether or not people make the predicted strategic move. Our data

[7]The formal structure of our C game corresponds to a bargaining game with endogenous timing and with observable delay (Hamilton and Slutsky, 1990).

show that the experimental subjects do after some time learn to make the predicted strategic move. Our results imply that the game theoretic intuition and modeling of strategic moves seem, at least in our simple setup and once players has been given enough time to understand the situation, to have a solid empirical foundation.

8 Appendix

8.1 Proof of Proposition 1:

a. In any subgame-perfect Nash equilibrium of the BM game player B demands $x_B^* = X - x_A$ when observing that player A demanded x_A with $x_A < X$. If player A demands the entire surplus, $x_A = X$, player B is indifferent between his feasible demands so any demand is optimal. It follows that the BM game has two pure-strategy subgame-perfect equilibria, described in the proposition.

b. Suppose first player B decides to see player A's demand. The subgame that follows is identical to the BM game, so in any subgame-perfect equilibrium of the C game player B gets at most ϵ if he sees player A's demand. Suppose next player B decides not to see player A's demand. With the assumption that the equal split results it follows that player B in any subgame-perfect equilibrium of the overall game gets half of X if he decides not to see player A's demand. Since by assumption $X/2 > \epsilon$ it is optimal for player B to decide not to see player A's demand.[8]

c. There are many Nash equilibria in this game and in some of them player B does not see player A's demand.[9] However the following result provides an argument for ignoring any equilibrium where player B does not see player A's demand. Consider the player B strategy that sees and best replies to any player A demand x_A, that is demands $X - x_A$ for any $x_A < X$ and makes some demand $y \in D$ for $x_A = X$. Denote this strategy $s_{BR,y}$ and denote the set of all such strategies BR.

Lemma 1. *Each of the strategies in BR weakly dominates any other player B strategy not in BR.*

Proof. Consider first any player B strategy that does not see player A's demand and demands x; denote this strategy s_x. Since $s_{BR,y}$ best replies to player A's demand it by definition earns at least as high a payoff against any player A demand as s_x. Furthermore, $s_{BR,y}$ earns a strictly higher payoff than s_x against any player A demand $x_A < X$ satisfying $X - x < x_A$ or $x_A < X - x$. Next, compare $s_{BR,y}$ and any player B strategy, denote it s', that sees player A's demand but is not in the set BR defined above. There is then at least one player A demand $x'_A < X$ such that s' does not play

[8] A reviewer pointed out that the conclusion that player B will see player A's demand will also hold if it were merely assumed that some Nash equilibrium giving player B at least ϵ is played in the subgame where player B decides not to see player A's demand; the player B strategy of not seeing player A's demand and making the corresponding equilibrium demand would then weakly dominate any player B strategy that sees player A's demand and that, on observing that player A demands $X - \epsilon$ or X, demands the residual.

[9] For example, the following strategies are in a Nash equilibrium: player B does not see player A's demand and demands one-half; player A demands one-half.

a best reply to x'_A. But then $s_{BR,y}$ earns a strictly higher payoff against x'_A than does s', and since $s_{BR,y}$ earns at least as high a payoff against any other player A demand, the lemma follows. □

Assuming that player B avoids weakly dominated strategies it follows that player B decides to see player A's demand. This being common knowledge, the players' equilibrium demands are identical to those in the BM game described above.

d. As in the UC game, the player B strategy of seeing player A's demand and playing a best reply weakly dominates all other strategies. The proof is identical and hence omitted. Assuming once more that player B does not play weakly dominated strategies, the equilibrium demands for the NC game is the same as for the UC game. ■

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